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Effects of maize and alfalfa genotypes on dairy cow performances

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Summary — In this trial, we attempted to evaluate the effects of alfalfa and maize genotypes fed to dairy cows. These genotypes were chosen from records of previous trials with sheep for either their high or low digestibility. Thirty-two cows were fed a diet based on maize silage ad libitum (M+ or M– genotype) and alfalfa (A+ or A–) pellets (4.35 kg/day) in a 2 x 2 factorial experiment. Silage intake, milk yield and composition, body weight and body condition scores were recorded during the 15-week experiment. The maize genotype of high digestibility (M+) tended to be ingested in larger quantities (14.4 vs 14.0 kg/cow/d) than the other genotype (M–), although showing a lower dry matter content (29.5 vs 31.2%). With this improved genotype, the milk yield was significantly higher (28.1 vs 26.9 kg/cow/day; $P = 0.01$) without decreasing effects in the fat and protein content of the milk, but with the cows increasing their body reserves (28.1 kg, $P < 0.01$). No differences were observed in the body condition scores. The alfalfa effects were not so acute, but the distribution of the improved genotype (A+) improved the daily milk yield (28.0 vs 27.0 kg/day, $P = 0.03$) and the body condition scores ($P = 0.04$). These principal effects appeared to be additive. The diet built with the best genotypes (M+ A+ diet) provided 2.2 kg milk/cow/day more than with the inferior ones (M– A– diet), displaying a higher body weight gain and better body conditions, without showing any negative effects on the fat and protein contents. Thus, the choice of a given genotype (maize or alfalfa in this case) may have strong effect on cow performances. In the European Union, where each farmer has a milk quota, the choice of an improved maize or alfalfa genotype could be essential in limiting production costs.

dairy cow / feeding value / alfalfa / maize / digestibility

Résumé — Effets du génotype de maïs et du génotype de luzerne sur les productions laitières. *Dans cet essai, les effets zootechniques de la variabilité génétique pour la valeur alimentaire existant chez la luzerne et le maïs ensilage ont été évalués. Nous avons alimenté des vaches laitières avec de l'ensilage de maïs distribué ad libitum et des bouchons de luzerne déshydratée et broyée (4,35 kg MS par vache par jour) dans un essai croisé à quatre modalités (quatre lots de huit animaux) durant 15 semaines. Nous avons utilisé deux génotypes de maïs (M+ et M–) et deux génotypes de luzerne (A+*

et A–) choisis pour leur digestibilité forte ou faible d'après des études précédentes menées sur moutons. La composition de ces fourrages et leur digestibilité in vivo (DOM) ont été déterminées (tableau I). Les quantités de fourrages ingérées, les productions laitières (quantité et composition du lait) ainsi que les variations de poids vifs vides et d'état corporel des animaux ont été enregistrées au long de l'essai. Quel que soit le génotype de luzerne, l'ensilage de maïs réalisé avec le génotype de bonne qualité (M+) a permis une production laitière plus élevée (28,1 vs 26,9 kg/jour, $p = 0,01$*; tableau II) sans dégradation des taux butyreux (43,9 vs 43,0 g/kg) et protéiques (30,5 vs 29,9 g/kg). Les animaux ayant reçu le maïs (M+) ont repris du poids alors que le poids des autres n'a quasiment pas varié (+28,1 vs 6,5 kg en 98 jours,* $p < 0,01$*). Nous n'avons en revanche pas noté de différences d'état corporel. Cet ensilage (M+) a été ingéré en quantité légèrement plus importante que l'ensilage (M–) (14,4* vs *14,0 kg/jour,* $p = 0,07$*) bien que sa teneur en matière sèche soit plus faible (29,5 vs 31,2%). Cette différence d'ingestion ne suffit pas à expliquer les meilleures performances zootechniques des animaux. Celles ci sont essentiellement dues à un écart important de valeur énergétique entre les deux hybrides. Par rapport à ces effets nets du génotype de maïs, les effets de la luzerne sont plus discrets : les animaux recevant la luzerne de bonne qualité (A+) ont produit plus de lait (28,0 vs 27,0 kg de lait brut/jour,* $p = 0,03$*) avec un état corporel stable (+0,0 vs – 0,2 point,* $p = 0,04$*). La composition du lait, les quantités de maïs ingérées et le poids des animaux n'ont pas été sensibilement modifiés. Les interactions entre les effets du maïs et ceux de la luzerne ne sont pas significatives (*$p > 0,45$*). La ration constituée des meilleurs génotypes (ration M+A+) a donc permis des performances bien supérieures à celles de la ration (M–A–) bien que ces 2 rations extrêmes aient été ingérées en quantités comparables (21,1 kg MS/vache/jour). La production de lait brut a été supérieure de près de 10% (28,5 vs 26,3 kg par vache et par jour,* $p < 0,05$*) sans détérioration des taux butyreux et protéiques (respectivement 43,4 et 30,4 vs 43,2 et 30,1 g/kg). Ces performances n'ont pas été réalisées au détriment des réserves des animaux qui ont repris du poids et amélioré leur état corporel. Ainsi la variabilité génétique pour la valeur énergétique mise en évidence chez deux espèces de plantes fourragères s'est traduite par des différences non négligeables de performances zootechniques. À l'heure où la réduction des coûts d'exploitation devient une nécessité pour l'agriculture, l'amélioration génétique de la qualité des fourrages semble être une voie à ne pas négliger.*

valeur alimentaire / vache laitière / maïs ensilage / luzerne

INTRODUCTION

Among the various ways of improving the quality of forage for ruminants, such as management, choice of harvest date or storage, plant breeding should be one of the most reasonable ways. It supposes a genetic variability within each given forage species and useful criteria available for breeders. It is now well accepted that a genuine genetic variation for digestibility traits has been found in some species. This variation has been detected in the morphological (eg, the leaf to plant ratio) or chemical composition of forage material or obtained from in vitro or in vivo experiments. The forage species involved in in vivo measurements with standard sheep were barley straw (Herbert et al, 1994), timothy (Mason and Flipot, 1988), alfalfa (Thomas et al, 1968; Wilson et al, 1978; Émile and Traineau, 1993), corn silage (Andrieu and Demarquilly, 1974; Gallais et al, 1976; Deinum et al, 1984; Barrière et al, 1991, 1992) or rapeseed (Lancaster et al, 1990; Émile et al, 1993b).

Studies involving dairy or fattening cattle have appeared less frequently. These are, however, still essential i) because of specific differences between animal species and their forage utilization, as reported by a recent review (Dulphy et al, 1994), and ii) because the specificity of the metabolisms devoted to meat or milk production must be taken into account. Studies have shown the effects of the genotype of maize silage on milk yield (Barrière and Émile, 1990) or forage intake (Barrière et al, 1995). Similar experiments have been carried out with cows fed ad libitum alfalfa green chopped forage (Emile et al, 1993a, 1995), pointing out in the same way the effect of alfalfa genotypes on intake and milk yield. In addition, alfalfa pellets given with maize silage to high yielding dairy cows may provide an interesting diet for the production of milk as shown by Mauries (1991) and Journet (1992).

The objective of this trial was to evaluate the effects of alfalfa genotypes, as dried pellets, and maize genotypes, as silage, when given together to dairy cows. Maize silage and alfalfa genotypes were chosen according to their feeding quality traits, which are estimates based on previous experiments with sheep or lactating dairy cows.

MATERIALS AND METHODS

Forage, animal and experimental design

The experiment was conducted at INRA Lusignan (France) during the winter 1992–1993. Maize genotypes were Inra 258 (M+), an old cultivar of high digestibility, and Rh 162 (M–), a newly registered hybrid with a lower digestibility. Their digestibilities were, respectively, 72.9% in 36 observations and 65.1% in four observations taken from our previous trials (Barrière *et al*, 1992). They were cropped in the same manner and their harvest dates were carefully chosen in order to obtain a similar dry matter (DM) content. Alfalfa genotypes were 63-28P (A+), an experimental synthetic with an improved digestibility, and Europe (A–) as control. In a previous study we found, by pooling 66 comparisons, that their digestibilities were, respectively, 67.9 and 65.2% (Émile and Traineau, 1993). For both cultivars, fresh forage was chopped in May, June and July (three consecutive cuts), then dried, ground (4.5 mm; Promill BB48) and pelleted (8 mm diameter).

Among the experimental Holstein herd, 32 mid-lactation cows were blocked into eight groups of 4 animals, according to the calving date (93 ± 12 d in milk), parity (2 blocks of primiparous cows), milk yield (32.9 ± 5.7 kg) and body weight (626 ± 71 kg). They were then assigned to a 2 x 2 factorial experiment with the two genotypes of maize silage (M+, M–) and the two genotypes of alfalfa offered as pellets (A+, A–). Thus, the four experimental treatments were compared using eight cows for each treatment.

Cows were housed in pens of 8, which were equipped with individual feeding gates allowing the evaluation of individual intakes. During a 4-week pretrial period, cows were fed a maize silage diet. They were then allowed 2 weeks to adjust to the gates. Data recorded during this pretrial period were used as covariates for the computing of milk yield and milk composition. For the maize silage intake, covariates were based on data taken from the last pretrial week. During the 15 experimental weeks, cows were fed a diet of maize silage given ad libitum, 4.4 kg DM alfalfa pellets, 0.14 kg urea, 0.35 kg DM protected soya-rape cakes (Protane SG - commercial product of CCLP: 1.15 UFL, 391 g PDIN, 385 g PDIE - DM basis) and a premix of minerals and vitamins in accordance with the requirements (INRA, 1988). Taking into account the theoretical feeding value of maize silage and alfalfa and according to the energetic and nitrogen requirements, this basic diet should have allowed a daily milk yield of 24.5 or 19.5 kg, respectively, for the multiparous and primiparous cows. The expected milk yields were calculated (with a weekly persistence equal to 97.5 and 98% for the multiparous and primiparous cows, respectively). Additional concentrates (Protane 120 - commercial product of CCLP: 1.03 UFL, 138 g PDIN, 138 g PDIE - DM basis) consistent with these expected yields were then given individually in the milking room (1 kg concentrate/ 3 kg milk above those basic levels). The average amount was 1.82 kg DM concentrate/cow/d during the experiment (from 0.5 to 4.3 kg). The forage to concentrate ratios were 88:12 when considering alfalfa pellets as forage.

Measurements and analysis

Throughout the experiment, cows were fed at 11:00, and refusals were daily removed at 07:30. Diet refusals were recorded 4 day a week. The amount of maize for each cow was adjusted daily according to the DM intake of the previous day and in order to ensure a 10% feed refusal. Alfalfa pellets were given on top of the maize diet, 2 or 3 times a day, so that refusals would not occur.

Milkings were at 07:30 and 16:30. Milk samples were taken twice a week from two consecutives milkings and analysed for fat and protein content. Cows were weighed on two consecutive days at the beginning and at the end of the trial and twice a month during the experiment.

Empty body weight (EBW) changes were then calculated according to Chilliard et al (1987). Body condition (BC) scores were determined by a visual evaluation each month on a five-point scale (ITEB, 1984). These evaluations were always performed by the same person. The energy balance (feed unit for milk, UFL per animal per day; 1 UFL = 1.7 Mcal net energy) was calculated by the difference between animal needs and food supplies: the maintenance, the milk yield energetic requirements and the negative interactions between forage (maize and alfalfa) and concentrates were estimated according to Faverdin et al (1987). The protein balance was expressed in the same way, with digestible proteins available in the intestine (PDIN and PDIE).

Maize silage and alfalfa pellets digestibilities were measured on six wethers kept in individual digestibility crates. Three replicates were performed with sheep fed ad libitum on each maize genotype and 3 on each alfalfa genotype with sheep kept on maintenance (45 g DM/kg metabolic weight [MW]). The animals received a nitrogen and mineral supplement in order to optimize the rumen activity. Daily representative samples of the offered forage and of the faeces were taken and submitted to a basic chemical analysis (ashes, crude protein as 6.25 x Kjeldahl nitrogen, crude fibre using the Weende method; starch content by the Ewers method). Apparent organic matter and crude fibre digestibilities (OMD and CFD) were then recorded and the energy values computed according to Andrieu and Demarquilly (1987).

Statistical analysis

Results were assessed by an analysis of variance as a 2 x 2 factorial design by the general linear model procedure of the Statistical Analysis System Institute (1990), using as basic data the average value of the 15 weeks for each traits. Concerning the intake, the milk yield and milk quality, the model was $Yijk = \mu + \beta(YPT) + Mi + Aj + Ck + MAij + MCik + ACjk + Eijk$, where *Yijk* is the dependent variable for the cow fed the maize *i* and the alfalfa *j* and belonging to the block *k*; μ is the population mean for the variable; β(YPT) is the covariates effect (data collected during the pretrial period); *Mi* is the effect of maize *i*; *Aj* is the effect of alfalfa; *Ck* is the effect of the block *k*; *MAij*, *MCik* and *ACjk* the crossed effects between, respectively, the maize *i* and the alfalfa *j*, the maize *i* and the block *k*, the alfalfa *j* and the block *k*; and *Eijk* is the random error associated with observation *ijk*. The body weight and body condition were analysed on variations between the beginning and the end of the experimental period using the same model except for the covariate. Comparisons between the extreme diets (M+A+ and M–A–) were performed using a Bonferonni test when means were not covariate-adjusted means. Neither maize x alfalfa interactions nor maize x block or alfalfa x block were found ($P > 0.45$); hence, their effects were pooled into the error term and only the principal effects are presented in the tables.

RESULTS

The main characteristics of the maize silage and alfalfa pellets are given in table I. Cow intake and production traits are listed in table II and figures 1, 2 and 3.

Feeding value

The OMD of the M+ silage was higher than that of the M– (70.3 vs 66.1%, on average, of the 3 replicates; confidence limit = 2.3), related to a higher CFD (56.9 vs 43.4%; confidence limit = 4.8), and despite a lower starch content (23.6 vs 28.8%). The A+ genotype had a lower crude fibre content, a higher protein content and a higher digestibility (62.2 vs 60.8%; confidence limit = 2.3) than the A-genotype.

Dry matter intake (DMI)

Total DMI was high (mean value: 21.1 kg DM/cow/d) despite the relatively low DM content of silages. No problems were encountered in obtaining a complete consumption of the pellets (4.35 kg DM/cow/day). Maize DMI (table II) was slightly reduced in cows fed M– (14.0 vs 14.4 kg/cow/day; $P = 0.07$), although DM content was higher (31.2 vs

Table I. Main characteristics of the maize silage (genotypes M– and M+) and the alfalfa pellets (genotypes A– and A+) given to the cows. Chemical composition. In vivo evaluation with sheep.

	Maize silage		*Alfalfa pellets*	
	M–	*M+*	*A–*	*A+*
Organic matter content (%)	95.4	94.0	89.1	89.0
Crude protein content (%)	7.6	8.4	17.2	17.7
Crude fibre content (%)	20.4	20.2	26.9	26.3
Starch content (%)	28.8	23.6	–	–
Volontary dry matter (DM) intake (g DM/kg $MW^{0.75}$)	54.8	59.1	46.3	46.0
Organic matter digestibility (%)	66.1	70.3	60.8	62.2
Crude fibre digestibility (%)	43.6	56.9	41.0	38.8

29.5%). Intakes of maize were not significantly different between the A– and A+ diets (14.4 vs 14.1).

Milk yield and composition

Milk production was higher ($P = 0.01$) with the M+ diets than with the M– diets (table II): 28.1 and 26.9 kg/cow/d, respectively. It was also greater with A+ diets compared with A– diets with a difference of 1.0 kg/cow/d (28.0 vs 27.0%, P = 0.03). Cows fed with a M+A+ diet produced 2.2 kg/cow/d more than those fed with a M–A– diet (28.5 vs 26.3 kg, $P < 0.05$). Differences appeared in the first week and were staged throughout the experimental period (fig 1). Despite no significant differences, milk fat contents seemed to be reduced with A+ diets compared with A– diets (–0.5 points) and to be increased with M+ diets compared with M– diets (+0.7 points). Fat-corrected milk yield (4% FCM) and daily fat yield tended to be higher with M+ diets than with M– diets ($P = 0.03$ and $P = 0.06$, respectively). The milk protein content was neither influenced by the maize genotype nor by the alfalfa one. The effects of maize on the daily protein yields were positive and highly significant ($P < 0.01$).

Body weight and body condition

Body weight variations (EBW) were very much dependent on the maize genotype ($P < 0.01$). Cows fed with the M+ genotype gained an average of 28.1 kg during the experimental period (average daily gain [ADG] of 287 g/d in 98 days), while cows fed with the M– genotype gained only 6.5 kg (ADG = 66 g/day). No alfalfa genotype effect emerged in this trait. The body condition change was significantly influenced ($P = 0.04$) by the nature of the alfalfa fed. Animals fed A+ diets maintained their body score while those fed with A– diets lost 0.2 points.

Energy balance

According to forage OMD, concentrate composition and diet intake, the energy supplies of the total diets (table III) increased from 16.6 UFL (diet M–A–) to 18.1 UFL/cow/day (diet M+A+). The energy balance was slightly negative for the four diets (–0.9 to –0.2 UFL/cow/day). The average nitrogen content of the diets was 14%. The protein supplies increased from 1 762 to 1 865 g PDIN and from 1 713 to 1 812 g PDIE. The

Table II. Effects of maize (M) and alfalfa (A) genotypes on dry matter (DM) intake, milk yield and milk composition [1].

	Diets					Principal effects				
	M–A–	*M–A+*	*M+A–*	*M+A+*	*ETR*	*Maize*		*Alfalfa*		*Comparison* [3]
						F	Pr > F	F	Pr > F	
Maize silage (DM kg) [2]	14.2 ^{ab}	13.9 ^{a}	14.6 ^{b}	14.2 ^{ab}	0.6	3.6	0.07	2.0	0.17	–
Total DM intake (kg)	21.0	20.7	21.4	21.1						
Milk (kg)	26.3 ^{a}	27.5 ^{ab}	27.8 ^{b}	28.5 ^{b}	1.6	7.9	0.01	5.2	0.03	*
FCM (kg) [2]	28.0 ^{a}	28.8 ^{ab}	29.1 ^{ab}	29.9 ^{b}	1.4	5.1	0.03	2.6	0.12	–
Fat yield (g) [2]	1 155 ^{a}	1 184 ^{ab}	1 208 ^{ab}	1 234 ^{b}	73	4.0	0.06	1.2	0.30	–
Protein yield (g) [2]	801 ^{a}	810 ^{ab}	839 ^{bc}	858 ^{c}	33	13.3	0.00	1.4	0.25	–
Fat content (g/kg) [2]	43.2	42.9	44.3	43.4	2.0	1.2	0.29	0.5	0.48	–
Protein content (g/kg) [2]	30.1	29.7	30.6	30.4	1.2	2.9	0.10	0.6	0.44	–
Mean body weight (kg)	622	611	637	619						
Weight change (EBW kg)	6.4 ^{a}	6.6 ^{a}	26.7 ^{ab}	29.4 ^{b}	20.4	8.7	0.00	< 0.1	0.86	ns
Body condition change	–0.3 ^{a}	0.0 ^{ab}	–0.1 ^{ab}	0.1 ^{b}	0.2	2.1	0.17	4.6	0.04	ns

[1] Residual degrees of freedom (df) were 21 or 22 according to the presence or absence of a covariable; [2] covariate-adjusted least squares means; [3] comparison between extreme genotypes diet: M+A+ *vs* M–A–. Significance at $P < 0.05$ level. Bonferroni test; ^{abc} numbers in same row with similar superscripts do not differ at $P < 0.05$. EBW = empty body weight; FCM = fat - corrected milk.

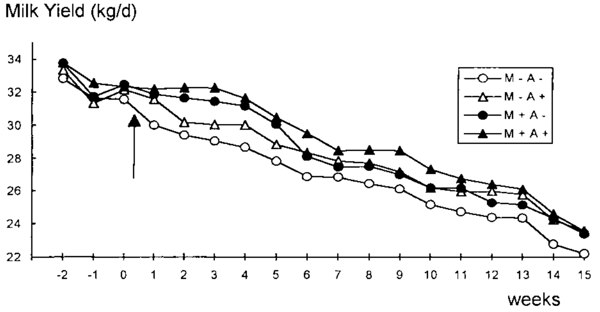

Fig 1. Effects of the four diets on milk yield (kg/cow/d). M+ and M– maize genotypes crossed with A+ and A– alfalfa genotypes.

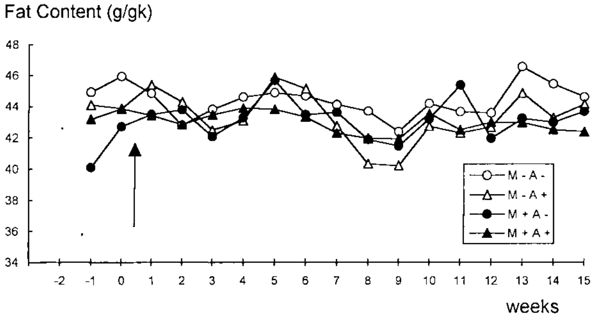

Fig 2. Effects of the four diets on fat content (g/kg). M+ and M– maize genotypes crossed with A+ and A– alfalfa genotypes.

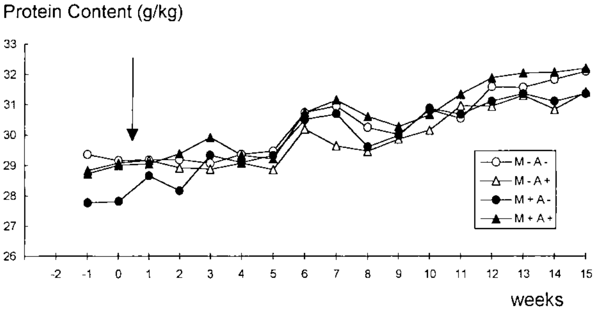

Fig 3. Effects of the four diets on protein content (g/kg). M+ and M– maize genotypes crossed with A+ and A– alfalfa genotypes.

PDI balance decreased from –2 g (M+A+ diet) to –63 g (M–A+ diet).

DISCUSSION

Forages feeding value

The diet energy balances were slightly negative. This result is quite amazing as cows were unlikely to have been kept in underfed conditions. They gained weight during the trial, at least cows fed M+ genotype, and with our feeding management, were able to react to contingent feeding value differences. Among the different terms involved in the balance, this may likely be related to the evaluation of the energy value of the diet and probably, more specifically, to the in vivo maize evaluation. By using an evaluation based on the chemical composition of the forage (protein, crude fibre and starch according to Dardenne et al, 1993), we

Table III. Energy (UFL/cow/d) and nitrogen (PDIN and PDIE; g/cow/d) balances of the 4 experimental diets given to the cows.

	M–A–	*M–A+*	*M+A–*	*M+A+*
Energy supplies (UFL/cow/d)	16.6	16.9	17.8	18.1
PDIN supplies (g/cow/d)	1 762	1 769	1 854	1 865
PDIE supplies (g/cow/d)	1 713	1 724	1 798	1 812
Energy needs (UFL/cow/d)	17.5	17.8	17.9	18.3
PDI needs (g/cow/d)	1 755	1 787	1 800	1 845
Energy balance (UFL/cow/d)	–0.9	–0.9	–0.1	–0.2
PDIN balance (g/cow/d)	+7	–18	+54	+20
PDIE balance (g/cow/d)	–42	–63	–2	–33

obtained higher OMD values (73.6 and 71.8% for M+ and M–, respectively) which were consistent in observed performances. As noted in other experiments, in vivo evaluation with sheep probably underestimated the energy value, resulting in this case in a negative balance. Although there was a large difference (4.2 points) between the OMD values of the 2 maize genotypes, this difference was half of what we had expected. The OMD of the M– genotype was low (66.1%) and led to a value of 0.82 UFL. This was nevertheless consistent with our previous observation (65.1%; Barrière et al, 1992) and led to an energy value 10% lower than the usual value of maize silage (71% OMD and 0.90 UFL). Cows fed this genotype reduced their milk production and stopped to restore body reserves. But for the M+ genotype, it is surprising that such a poor value (70.3%) was obtained compared with our previous measures (72.9% with 36 ± 0.7 samples). This poor value should not have allowed such production and body gain levels.

Effects of the maize genotype

The M+ genotype clearly allowed higher performances than the M– genotype. We indeed noted, with any of the alfalfa types, an increase in the milk production (1.1 kg FCM more) without any decreasing effect in fat and protein content. The difference in the energy balance between the two genotypes (+0.8 UFL/d) was in agreement with the observed difference in the ADG (+221 g/d). Thus, there was undoubtedly a maize genotype effect on cow performances. The maize intake (+0.4 kg/cow/d for the M+ genotype) was not sufficient to explain such a difference, which should mainly result from the variations in the digestibility of these hybrids. The observed energy value of the two genotypes can be evaluated by balancing animal requirements and diet supplies. The M+ genotype had then an observed energy value of 1.05 UFL/kg DM and the M–, 0.96 UFL. These high values agreed with evaluations carried out in other studies involving dairy cows (Barrière et al, 1995) where the observed energy value of maize genotypes increased from 0.85 to 1.12 UFL negatively related to the amount of concentrates in the diet. The difference between the two hybrids (0.09 UFL) was in agreement with the difference highlighted in the in vivo sheep evaluations in both this study (0.06 UFL) and the previous one (0.11 UFL; Barrière et al, 1992). Moreover, the marginal efficiency for milk production (kg milk/supplementary UFL) was probably limited by the cows high production level and this might have buffered the true difference between the M+ and M– genotypes.

The observed variations in hybrid digestibility were not related to variations in grain content, that were similar for the two hybrids (42.5 vs 40.0%). These variations may relate to variations in lignin content, and also to variations in phenolic acid content and monomeric composition of lignin (Argillier et al, 1995a). These variations could be somehow enhanced because of the small low grain content of the silage, but it is also worth noting that Barrière et al (1990) did not observe differences in dairy cow performances when fed silage of a 42 and 48% grain content.

Feeding value evaluations with sheep (OMD and CFD) were consistent with cow performances, and gave a good ranking of the genotypes. For breeders, the variations in digestibility could probably be easily estimated with a trait such as the one proposed by Argillier et al (1995b), computing, of the NIRS calibration, the digestibility of the nonstarch and nonsoluble carbohydrates part of the plant.

These results, pointing out a genetic variation for zootechnical performances, confirm other studies comparing two or more maize genotypes used as whole plant silage for feeding high yielding dairy cows (Barrière and Emile, 1990; Barrière et al, 1995). In those studies, the variation in milk yield with cows fed a low or high digestible hybrid neared 1.0 to 2.0 kg/cow/d and body weight variations were 10 to 30 kg during the 3 months of the experiment.

Effects of the alfalfa genotype

Compared to the maize effect, the alfalfa effects were not so acute. Nevertheless, the feeding of animals with the experimental alfalfa genotype A+ has a positive influence on the daily milk yield and on the body condition changes in cows. In previous experiments, but under different feeding conditions, we evidenced stronger positive effects (Émile et al, 1995) with the same genotypes given ad libitum as fresh forage without any other roughage. In the present trial, the percentage of alfalfa in the total diet was only 21%, lowering its effect. It also appeared that the dried, ground and pelleted forage could have a lower feeding value than the fresh forage, as previously observed by Demarquilly (1982) or Conrad and Klopfenstein (1988). This depression of digestibility is related to the fineness of grinding and to the relatively short time during which forage is exposed to the microflora in the rumen (Minson, 1990). This depression had probably also lowered the difference between the two genotypes, when pellets were given as the only feed to sheep. Nevertheless, in dairy cattle feeding, the use of high quality alfalfa pellets is of great interest (Peyraud et al, 1994) and this trial shows that plant breeders need to investigate this objective further.

As mentioned earlier, the principal effects (maize and alfalfa) hold concurrently. The M+A+ diet allowed a higher milk yield (8% more) and more FCM with a higher protein content than the M– A– one. Cows fed the M+A+ diet gained body weight and maintained their body condition scores which is not the case with cows fed the M–A– diet. Comparing these two extreme diets, the marginal efficiency of the energy supplied was about 1.2 kg of FCM for each extra UFL.

CONCLUSION

Genetic variation between maize hybrids for energy content was first pointed out in sheep measurements. These results showed that they could lead to significant variations in milk yield, milk quality and body weight conditions of the dairy cows. Because our dairy cattle feeding management was very similar to that of farmers for high yielding dairy cows, it is of great interest to note that the choice of genotype (maize or alfalfa in this case) is of economical importance in animal rearing. It could lead to strong variations in animal performances.

For plant breeders, the prediction of the efficiency of a genotype for dairy cow rearing must include digestibility and ingestibility topics. With a trait such as the one proposed by Argillier et al (1995b), it would be possible to breed genotypes with a good cell-wall digestibility and a good grain content. One of the greatest challenges for plant breeders, regarding maize but also alfalfa, would probably be the adjustment of a trait for the intake prediction.

Concurrent measurements by maize breeders of yield and whole plant digestibility are of agronomic and economic interest, in providing animal rearers maize hybrids suitable for all kinds of conditions. As pointed out by Utz et al (1994), the greatest economic maize breeding traits, at high animal performance levels, are those related to the energy content of the plant, rather than those related to the plant yield. However, at low animal performance levels, forage yield appeared as an important economic trait. These findings are probably not independent of the intake capacity of the animals. These results are probably also true for other forage species such as alfalfa. In the European Union, where milk production is limited by a quota for each farmer, the choice of a genotype (here, maize silage and alfalfa) could be the basis towards reducing production costs.

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